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Method and Apparatus for Generating Process Heat and/or Electrical Energy

CROSS REFERENCE TO RELATED APPLICATIONS

[0001] The present application is the National Stage Application of International Application No. PCT/EP2005/050260, filed January 21, 2005, which claims priority to DE 10 2004 006 516.0, filed on February 10, 2004.

BACKGROUND OF THE INVENTION

[0002] ~~This~~ The present invention relates to a method and apparatus for generating process heat and/or electrical energy for a machine for the production and/or finishing of a fibrous web, particularly a paper web or paperboard web.

[0003] The process heat for paper machines was produced hitherto by combustion of fossil fuels or waste products. The electrical energy for paper machines was produced in distant power stations.

SUMMARY OF THE INVENTION

[0004] The ~~object of the~~ present invention ~~is to create~~ provides an improved method and apparatus for generating process heat and/or electrical energy for a machine for the production and/or finishing of a fibrous web ~~of the type initially referred to~~. In particular, the present invention allows the use of renewable energies and/or alternative fuels ~~should also be possible~~.

[0005] ~~This object is accomplished in accordance with the invention in that~~ According to various embodiments, gas with the highest possible proportion of hydrogen is generated from the waste products resulting during the production and/or finishing of the fibrous web, and this hydrogen-rich gas is used for generating the necessary process heat and/or the necessary electrical energy.

[0006] ~~By virtue of this aspect of the invention, in particular~~ According to one or more embodiments, renewable energies and/or alternative fuels can be used ~~as well, in which case particularly~~ whereby the waste products from the machine contributing to or the paper machine involved in the production and/or finishing of a fibrous web can be put to sensible use. Furthermore, a decentralized generation of energy is ~~now~~ also possible.

[0007] Particularly, bark, fibers, edge cuttings and/or the like can be used as waste products.

[0008] The waste products used can also be transformed into methanol first. Alternatively or in addition to this, the use particularly of a so-called DMFC (Direct Methanol Fuel Cell) is also ~~conceivable~~possible.

[0009] According to ~~a preferred practical aspect of the method according to~~ one or more embodiments of the present invention, the waste products used are first conveyed to a reformer. ~~In this case~~ According to these embodiments, the hydrogen carbons of the waste products used can be transformed into a hydrogen-rich and carbon monoxide-rich gas by ~~means of~~ the reformer, for example through autothermic reforming, partial oxidation or vapor reforming.

[0010] To transform the carbon monoxide into another hydrogen-rich gas, the reformer can be followed by one or more shift stages.

[0011] ~~It is also an advantage particularly if~~ According to other embodiments, the reformer or the shift stage is followed by at least one more process stage for further reduction of the carbon monoxide.

[0012] ~~According to an expedient practical embodiment~~Still according to other embodiments, the reformer is followed by a stage for pressure swing adsorption. Alternatively or in addition to this, the reformer can also be followed, for example, by a stage for selective oxidation as a further process stage.

[0013] Should the waste products resulting during the production and/or finishing of the fibrous web not be sufficient to meet the energy requirement,

additional hydrogen carbons and/or additional H_2 can be fed to the reformer. ~~In this case~~According to these embodiments, it is ~~conceivable~~possible, for example, to supply additional hydrogen carbons in the form of natural gas, biomass, wood chips and/or the like. If H_2 is available, meaning if there is an H_2 grid for example, particularly H_2 can be supplied in addition as already mentioned.

[0014] The process heat and/or electrical energy is preferably generated in each ~~case~~ embodiment at that point of the machine at which it is required. In other words, the process heat and/or the electrical energy can be generated in each ~~case~~ embodiment, on, in or near the particular unit of the machine which is to be heated or supplied with electrical energy.

[0015] ~~It is an advantage for the~~ According to various embodiments, the process heat and/or electrical energy ~~to be~~is generated by a fuel cell from the acquired hydrogen-rich gas and/or from additional hydrogen taken from a grid or tank ~~for example~~. It is preferred for the process heat to be generated by ~~preferably~~ combusting the acquired hydrogen or methanol and/or additional hydrogen taken from a grid or tank ~~for example~~.

[0016] According to another aspect of the invention, an apparatus for generating at least one of process heat and electrical energy for a machine for at least one of production and finishing of a fibrous webi is provided, wherein the apparatus is configured to provide a hydrogen-rich gas having a highest possible proportion of hydrogen generated from waste products resulting during at least one of the production and finishing of the fibrous web, and the apparatus is configured to

utilize the hydrogen-rich gas for generating at least one of the process heat and the electrical energy. The fibrous web can be one of paper web or paperboard web and the machine can be configured for at least one of the production and finishing of the one of a paper web or a paperboard web. At least one of bark, fibers, and edge cuttings can be utilized as waste products and the apparatus can be configured to provide the hydrogen-rich gas generated from at least one of the bark, fibers, and edge cuttings. At least one of: i) the waste products utilized are first transformed into methanol, and ii) a DMFC (Direct Methanol Fuel Cell) can be utilized, and the apparatus can be configured to utilize at least one of the methanol and DMFC. The apparatus can include a reformer and the reformer can be configured to be first fed with the waste products. The reformer can be configured to transform hydrogen carbons of the waste products into a hydrogen-rich and a carbon monoxide-rich gas through autothermic reforming. The reformer can be configured to transform hydrogen carbons of the waste products into a hydrogen-rich and a carbon monoxide-rich gas through partial oxidation. The reformer can be configured to transform hydrogen carbons of the waste products into a hydrogen-rich and a carbon monoxide-rich gas through vapor reforming. The apparatus can include a shift stage for transforming carbon monoxide into another hydrogen-rich gas and can be followed by the reformer. The apparatus can include at least one more process stage for further reduction of carbon monoxide and can follow one of the reformer or a shift stage. The reformer can be followed by the shift stage for pressure

swing adsorption as a further process stage. The reformer can be followed by the shift stage for selective oxidation as a further process stage. The apparatus can be configured to feed at least one of additional hydrogen carbons and additional H_2 to a reformer when the waste products resulting during at least one of the production and finishing of the fibrous web are insufficient to meet an energy requirement. The reformer can be configured to be supplied with additional hydrogen carbons in the form of at least one of natural gas, biomass, and wood chips. The apparatus can be configured to generate at least one of the process heat and electrical energy at a point of the machine at which the at least one of the process heat and electrical energy is required. The apparatus can be configured to generate at least one of the process heat and the electrical energy at least one of on, in or near a particular unit of the machine that is to be one of heated or supplied with electrical energy. The apparatus can include at least one fuel cell and can be configured to generate at least one of the process heat and the electrical energy by at least one fuel cell from at least one of an acquired hydrogen-rich gas and additional hydrogen taken from at least one of a grid or tank. The apparatus can be configured to generate the process heat by combusting at least one of an acquired hydrogen, methanol and additional hydrogen taken from at least one of a grid or tank.

[0017] According to another aspect of the invention, a method for generating at least one of process heat and electrical energy for a

machine for at least one of a production and finishing of a fibrous web is provided, the method including: generating a hydrogen-rich gas having a highest possible proportion of hydrogen from waste products resulting during at least one of the production and finishing of the fibrous web, the hydrogen-rich gas is utilized for generating at least one of a necessary process heat and a necessary electrical energy, and hydrogen carbons of the waste products utilized are transformed into a hydrogen-rich and a carbon monoxide-rich gas by a reformer through at least one of autothermic reforming, partial oxidation, and vapor reforming.

[0018] Still according to another aspect of the invention, an apparatus for generating at least one of process heat and electrical energy for a machine for at least one of a production and finishing of a fibrous web is provided, wherein the apparatus is configured to provide a hydrogen-rich gas having a highest possible proportion of hydrogen generated from waste products resulting during at least one of the production and finishing of the fibrous web, the apparatus is configured to utilize the hydrogen-rich gas for generating at least one of a necessary process heat and a necessary electrical energy, the apparatus comprises a reformer and the reformer is configured to be first fed with the waste products, and the reformer is configured to transform hydrogen carbons of the waste products into a hydrogen-rich and a carbon monoxide-rich gas through at least one of autothermic reforming, partial oxidation, and vapor reforming.

BRIEF DESCRIPTION OF THE DRAWINGS

[0019] The present invention will be described in more detail in the following text using exemplary embodiments and with reference to the drawings, in which:

[0020] ~~f~~Figure 1 is a chart of the transformation of biomass (hydrogen carbons into hydrogen (H_2). ~~and~~

[0021] ~~f~~Figure 2 is a process chart of the generation of process heat and/or electrical energy for a machine for the production and/or finishing of a fibrous web.

VARIOUS EMBODIMENTS OF THE INVENTION

[0022] ~~An advantageous~~ According to one or more embodiments of the method and apparatus ~~according to~~ of the present invention, ~~for~~ the generation of process heat and/or electrical energy for a machine for the production and/or finishing of a fibrous web, particularly a paper web or ~~paperbard~~ paperboard web, is described in the following text with reference to ~~f~~Figures 1 and 2, purely by way of example. ~~Hence the machine in question can be, for example,~~ The apparatus according to the present invention can comprise a paper machine including an upstream stock preparation section and any units for finishing the fibrous web or paper web.

The apparatus of the present invention is configured to carry out the method according to the present invention for the generation of process heat and/or electrical energy for a machine for the production and/or finishing of a fibrous web, in particularly a paper web or paperboard web. Therefore, by way of example, the apparatus according to the present invention is described in the following text with reference to Figures 1 and 2.

[0023] To begin with, gas with the highest possible proportion of hydrogen is generated from the waste products resulting during the production and/or finishing of the fibrous web. This hydrogen-rich gas is then used to generate the necessary process heat and/or the necessary electrical energy.

[0024] The waste materials can be, for example, bark, fibers of no use for the subsequent production process, edge cuttings and/or the like, meaning biomass or hydrogen carbons in the general sense. Apart from biomass, particularly the use of natural gas, alcohols and/or the like is ~~conceivable~~possible.

[0025] The waste products used can also be transformed into methanol first.

[0026] Figure 2 shows a chart of the transformation of biomass (hydrogen carbons) into hydrogen (H_2), whereby apart from biomass the use of, for example, natural gas, alcohols and/or the like is also possible.

[0027] As is evident in the diagram in ~~f~~Figure 2, biomass or the waste products used can be fed first to a reformer 10. By ~~means of~~ this reformer 10, the hydrogen carbons concerned (C_nH_m) are transformed into a hydrogen-

rich gas and a carbon monoxide-rich gas. For this purpose, air as well as the hydrogen carbons C_nH_m are fed to the reformer 10. In the case of autothermic reforming and vapor reforming, water is additionally supplied ~~in addition~~. In the case of partial oxidation, only air is supplied. Through the upstream operation of the reformer 10, the respective energy carrier (e.g. biomass) can be transformed by combustion into hydrogen or a hydrogen-rich gas. In ~~the~~ this case ~~under consideration~~, for example, this takes place at a temperature of around 800°C.

[0028] The hydrogen carbons C_nH_m of the biomass or waste products used can be transformed into a hydrogen-rich and carbon monoxide-rich gas by ~~means of~~ the reformer 10, for example through autothermic reforming, partial oxidation or vapor reforming. To transform the carbon monoxide into another hydrogen-rich gas, the reformer 10 can be followed by a shift stage 12.

[0029] ~~In the case under consideration there follows, for example,~~ According to various embodiments, a vapor reforming stage in which hydrogen is obtained from hydrogen carbons C_nH_m can be performed in two steps. In the first step, the hydrogen carbon C_nH_m is first transformed in the reformer 10 into a hydrogen-rich gas and a carbon monoxide-rich gas. The resulting carbon monoxide (CO) is then separated off and mixed in the second step, i.e. in shift stage 12, with water or steam to create another hydrogen fraction. The applicable reaction equation is as follows:

$$CO + H_2O \rightarrow CO_2 + H_2.$$

H_2 and CO are not separated therefore. CO and H_2O react "selectively" with each other.

[0030] The reformer 10 or the shift stage 12 can be followed by at least one more process stage for further reduction of the carbon monoxide.

[0031] ~~In this case~~ According to various embodiments, the reformer 10 or the shift stage 12 can be followed, for example, by a stage 14 for pressure swing adsorption and/or a stage 16 for selective oxidation as a further process stage.

[0032] The stage for pressure swing adsorption (PSA) can comprise in particular, the following steps:

- adsorption at high pressure
- pressure decrease
- flushing with product gas at low pressure
- pressure increase with untreated gas or product gas.

[0033] In the case of selective CO oxidation (stage 16), the carbon monoxide can be oxidized selectively to CO_2 through the supply of oxygen or air and the help of a catalyst. The hydrogen content of the synthesis gas is at least largely retained thereby.

[0034] Should the waste products resulting during the production and/or finishing of the fibrous web not be sufficient to meet the energy requirement, additional hydrogen carbons can be supplied to the reformer 10. In this case

these additional hydrogen carbons can be supplied to the reformer 10 in the form of, for example, natural gas, biomass, wood chips and/or the like.

[0035] The process heat and/or electrical energy is preferably generated in each case at that point of the machine at which it is required. In other words, the process heat and/or the electrical energy can be generated in each case on, in or near the particular unit of the machine which is to be heated or supplied with electrical energy.

[0036] As is evident in ~~f~~Figure 2, the process heat and/or electrical energy can be generated in particular, by means of at least one fuel cell 18 from the acquired hydrogen-rich gas. Hence, the process heat is preferably generated by combustion of the acquired hydrogen or methanol.

[0037] Figure 2 shows a process chart of the generation of process heat or electrical energy for a paper machine 20 which is fed with wood, fibers and/or the like and delivers the paper 10.

[0038] As is again evident in this process chart, the waste or biomass resulting in the paper machine 20 is fed to a reformer 10. ~~In the case under consideration~~ According to these embodiments, this reformer 10 is fed in addition with natural gas.

[0039] The hydrogen H_2 acquired via the reformer 10 is fed on the one hand, directly to the paper machine 20 as fuel. On the other hand, hydrogen H_2 generated by the reformer 10 is fed to at least one fuel cell 18, which ~~in the~~

~~case under consideration~~ according to these embodiments, delivers both process heat and electrical energy for the paper machine 20.

[0040] **List of reference numerals**

10	Reformer
12	Shift stage
14	Stage for pressure swing adsorption
16	Stage for selective oxidation
18	Fuel cell
20	Paper machine